BRAIN AND LANGUAGE **14**, 15–33 (1981)

The Role of the Right Hemisphere in the Apprehension of Complex Linguistic Materials

WENDY WAPNER, SUZANNE HAMBY, AND HOWARD GARDNER

Boston Veterans Administration Medical Center and Aphasia Research Center,
Department of Neurology, Boston University School of Medicine,
and Harvard Project Zero

To secure information on which aspects of linguistic functioning might be mediated by the nondominant hemisphere, a test battery assessing sensitivity to narrational and humorous materials was administered to a population of right-hemisphere-damaged patients, as well as relevant control groups of normal, aging, and aphasic individuals. While elementary linguistic functioning was adequate, the right-hemisphere-injured groups exhibited consistent difficulties in respecting the boundaries of a fictive entity, assessing the plausibility of elements within a story or joke, selecting the appropriate punch line for a joke, and integrating elements of a story into a coherent narrative. Certain elements—specifically emotional content and noncanonical facts injected into a narrative—also posed characteristic difficulties for these patients. The results suggest that, in contrast to the other populations, right-hemisphere patients exhibit special difficulties in processing complex linguistic entities and in utilizing the surrounding context as they assess linguistic messages.

INTRODUCTION

The left hemisphere has traditionally been viewed as the hemisphere dominant for linguistic functions. For the most part, this view is justified:

The research reported in this paper was supported by the National Institute of Neurological Diseases, Communication Disorders, and Stroke (NS 11408); the Veterans Administration; and Harvard Project Zero. We wish to thank our colleagues, Michael Cicone, Dean Delis, Murray Grossman, Dee Michel, Barbara Shapiro, and Edgar Zurif, for their collaboration on various aspects of this program of research. Thanks are due, too, to an anonymous (but recognizable) reviewer for *Brain and Language*. We are especially grateful to Dr. Lillian Gray of the Massachusetts Rehabilitation Hospital, Dr. Anna Pomfret of the New England Rehabilitation Center, and Drs. Michael Alexander and James Liljestrand of the Braintree Rehabilitation Hospital for their help and support in the conduct of the various studies reported here. Earlier versions of this paper were presented at the International Neuropsychology Symposium, Dubrovnik, Yugoslavia, June, 1979, and at the Academy of Aphasia, San Diego, CA, October, 1979. Address reprint requests to: Howard Gardner, Psychology Service, 116B, Veterans Administration Medical Center, 150 South Huntington Avenue, Boston, MA 02130.

0093-934X/81/050015-19$02.00/0
Copyright © 1981 by Academic Press, Inc.
All rights of reproduction in any form reserved.

research on the basic components of language—phonology, syntax, and semantics—has established that language is among the most highly lateralized of human capacities. To the extent that the functions of the right hemisphere have been specified, discussion has centered on its importance in dealing with certain kinds of information—such as visual–spatial or emotional contents—and on its centrality in certain styles of information processing—such as Gestalt or intuitive processing. There are also scattered suggestions that the right hemisphere assumes a role in the processing of high-level conceptual or ideational materials (cf. Caramazza, Gordon, Zurif, & DeLuca, 1976; Eisenson, 1962; Lezak, 1979), but little consideration of the extent to which such deficits might be secondary to or confounded with problems in dealing with certain kinds of linguistic entities.

Only a few researchers have suggested that the right hemisphere may play a role in linguistic processing, and even these suggestions have been extremely general. Furthermore, it is not known whether, in dealing with language, the right hemisphere assumes a role in handling specific kinds of content (e.g., emotional information); in employing a particular type or style of processing (e.g., holistic) which is used across many different kinds of contents and information; in dealing with materials at a certain level of abstraction (e.g., syllogisms); or in some as-yet-unspecified fashion.

The meager evidence pertinent to the role of the right hemisphere in language processing comes from a number of scattered sources, methods, and populations. Over a century ago Jackson (1932) suggested that the right hemisphere may be capable of producing automatic speech, for example, in severely aphasic patients. Analogously, over the years, students of global aphasia have attributed the few wishes which these patients can articulate, and the few messages which they can understand, to the latent capacities of the right hemisphere.

Supplementing these impressions (gained primarily from observations of pathological populations) are studies with normal populations which have suggested further linguistic processes in which the right hemisphere may be involved. Studies using dichotic listening techniques have documented right-hemisphere participation in the processing of vowels, of intonational contours, and of affectively toned stimuli (Blumstein & Cooper, 1974; Heilman, 1976; Kimura, 1967, 1973).

Other, more specialized populations have also contributed to an emerging picture of right-hemisphere capacities. Investigations of young hemispherectomized patients and individuals who have learned language at a relatively late date have documented the potential of the right hemisphere to assume at least some of the linguistic functions normally associated with the left hemisphere (Dennis, 1978, 1980; Dennis & Whitaker, 1976; Woods, 1979). Further evidence on this issue emerges from studies of commissurotomized patients whose right hemisphere has been surgically isolated from the left hemisphere. Though the generality of the results on this unusual patient population has on occasion been challenged (Whitaker, 1978), the thrust of investigations with this population has suggested that the isolated right hemisphere possesses a fairly rich lexicon, some ability to read, and limited syntactic capacities. Written and oral expression, however, are essentially absent in the isolated right hemisphere of these patients (Gazzaniga, 1970; Sperry, 1974; Zaidel, 1973, 1977, 1978a, b).

Quite possibly the richest source of information on right-hemisphere functioning comes from normal individuals who have suffered right-hemisphere damage secondary to stroke or trauma. Superficially, these patients seem to retain the basics of language. However, while their speech may be literally unexceptionable, clinical inspection reveals that such patients often seem to lack a full understanding of the context of an utterance, the presuppositions entailed, or the tone of a conversational exchange. Demonstrations of difficulty exhibited by right-hemisphere patients in dealing with abstract sentences, logical reasoning, and a coherent stream of thought, are also potentially relevant to a documentation of right-hemisphere involvement in linguistic processing (cf. Caramazza et al., 1976; Eisenson, 1962; Lezak, 1979). In addition, the language of such patients is often excessive and rambling; their comments are often off-color and their humor frequently inappropriate; they tend to focus on insignificant details or make tangential remarks; and the usual range of intonation is frequently lacking (Gardner, 1975; Geschwind, 1976; Heeschen, 1979; Ross & Mesulam, 1979; Weinstein, 1971). Thus, while less concerned with "traditional" linguistic components, the right hemisphere appears vital in the processing of extra- or paralinguistic facets of language—facets which contemporary students of language would include as part of pragmatics or the discourse function of language (Bates, 1976; Sadock, 1974; Searle, 1969).

Some recent experimental work supports these claims. There is emerging evidence that right-hemisphere patients have difficulty in processing humorous material (Gardner, Ling, Flamm, & Silverman, 1975), discerning the connotations of common words (Gardner & Denes, 1973), appreciating antonymic contrasts (Gardner, Silverman, Wapner, & Zurif, 1978), interpreting figures of speech (Winner & Gardner, 1977), using figures of speech in appropriate contexts, and appreciating and labeling affectively toned situations presented to them in written or pictorial form (Cicone, Wapner, & Gardner, 1980; Heilman, 1976). For the most part, however, the proposed picture of right-hemisphere linguistic functions has yet to be substantiated.

To secure systematic information on the linguistic capacities of the right hemisphere, and to evaluate the aforementioned clinical impressions, our research group has developed and administered a new set of tests to a population of right-hemisphere patients. These tests feature complex narrational materials, which patients are required to recall, order, integrate, assess, and use as a basis for logical inferences. We have sought to determine whether right-hemisphere patients exhibit problems dealing with certain kinds of content (e.g., emotional subject matter); executing certain kinds of processing (synthesizing information); processing narratives presented in different media (e.g., linguistic versus nonlinguistic (film) presentation); and dealing with certain linguistic entities (e.g., jokes). From this inquiry, which deliberately taps narrational skills from a number of diverse angles, we hope to uncover basic principles which might account for the pattern of results recently obtained with right-hemisphere patients.

In this paper we report results gained with an initial set of patients. In addition to providing quantitative data, we have given considerable attention to the type and quality of responses which have typically emerged. To the extent possible, we have indicated which findings characterize the gamut of right-hemisphere patients, which seem restricted to subpopulations. Because of their pronounced language deficits, it has not proved possible to use aphasic patients as a brain-damaged control group in all phases of the study; however, whenever possible, comparison to the performance of aphasic subgroups has been included. In addition, we report results obtained with normal middle-aged and normal aging populations.

TEST BATTERY

1. Stories Featuring Different Contents

The ability of patients to recall story content and to integrate particular story elements has been tested through the administration of three stories. One story concerns a farmer and his hired hand who will not fix a leaking barn; a second concerns a grocer who is robbed; the third describes a fireman and a little girl who has secretly hitched a ride on a fire engine just before a fire breaks out.

Each story has been so composed that it can be elaborated on through the insertion of certain additional elements: spatial elements, emotional elements, or noncanonical (bizarre) elements. Each patient hears the three stories with a different element added in each story. Thus, the spatial version of the Grocer Story includes sentences crucial to understanding spatial relations in the story (e.g., The large moving van concealed the front of a police station). The noncanonical version of the Farmer Story includes bizarre sentences (e.g., The farmer decided to give the hired hand a raise). In the emotional version of the Fireman Story, the bare narrative is elaborated with words and phrases which convey the emotional states of characters explicitly or implicitly (e.g., The little girl began crying; her heart pounded as she crept in). In addition to hearing these three stories, each featuring a different elaboration, all subjects hear a longer fourth story which includes all three elaborations—spatial, emotional, and noncanonical.

In sum, each patient hears four stories. After each, the patient is asked to retell the story in as much detail as possible and is then asked a set of questions about the main points of the story and the particular elements which require integration into the narrative. If a subject answers incorrectly, four answers are read to him and he is asked to select the most appropriate response.

2. *Story Arrangement Task*

A story arrangement task was administered, in which patients are presented in a random order sentences written on individual cards, and are asked to arrange them into a coherent narrative (cf. Delis, 1980). By this manipulation, memory is eliminated as a component necessary for accuracy in integrating story elements and/or in successfully handling certain kinds of content. In one story, the sentences can be correctly ordered only if the subject is sensitive to spatial information. For example, a baseball is hit out of a ball park and the subject must envision the trajectory of the ball in order to organize the sentences correctly. Success on other sets of sentences depends, respectively, on sensitivity to temporal information (which event is likely to happen first), or to categorical information (which of the designated elements belong to a superordinate set, such as items of clothing).

3. *Stories Presented in Linguistic and Visual Mediums*

To ascertain whether right-brain-damaged patients would have difficulty abstracting the point or moral of a story (a task requiring the ability to integrate story elements, assess major themes, and make appropriate inferences), longer fable-like stories were presented. Moreover, to probe whether difficulties with this task are due to impairments in their ability to appreciate linguistically presented narratives, or in their ability to handle narratives per se, subjects were presented stories in both linguistic (oral–auditory) and nonlinguistic (filmic) versions.

The filmic version is a 7-min silent film, *The Fence*, which depicts a conflict between two neighbors and its eventual resolution. The film has been converted into a text form, which is administered orally, and a control story, *The Silver Hammer*, has been constructed to match *The Fence* in length, complexity, and other story-grammatical features (Mandler & Johnson, 1977; Stein & Glenn, 1979). To ensure that any differences found between stories were due to medium of presentation and not to differences in the content of the two stories, half of the subjects saw the movie version of *The Fence* while the other half heard the oral narrative along with hearing the story of *The Silver Hammer*.[1] As in the first story test, immediately after the story is presented, patients are asked to retell the story as accurately as possible. Thereafter, they are posed a series of questions probing factual information, inferences about the motives of the characters, knowledge of the plot, and moral of the story. Again, subjects were given a multiple choice if they were unable to correctly answer the quesions.

4. Choosing Punch Lines for Jokes

To investigate whether the inappropriate humor displayed by right-hemisphere patients in clinical settings could be documented in a formal testing situation, a study was designed specifically to measure appreciation of humor in a linguistic modality (cf. Michel, 1980). Patients hear the bodies of 16 jokes and are asked to choose the correct punch line from an array of four multiple choices. The endings are constructed so that three of them directly follow from the body of the joke (the correct funny ending, a straightforward but not funny ending, and a sad, pathetic ending); the fourth choice is a nonsequitur ending—one which does not follow from the body of the joke. Patients are also asked to justify their choices on a subset of the items.

METHODS

Subjects

Sixteen right-hemisphere brain-damaged patients, 13 males and 3 females, were tested. Whenever possible, patients received the entire battery of tests. All subjects were right-handed native English-speaking patients from the neurological wards of the Boston Veterans Administration Hospital or the New England Rehabilitation Center. Subject ages ranged from 50 to 72; the mean age was 61. Twelve patients were under 65 and four patients were over 65. All subjects had unilateral right-hemisphere cortical disease, as confirmed by CT scan. Fifteen of the sixteen patients suffered brain damage as a result of a right-hemisphere stroke; one patient had a large frontal meningioma evacuated.

On the basis of radiological information (CT scan and EEG report) and clinical signs (hemiplegia, sensory loss, and field cuts), these patients were classified into one of four groups: (a) those with lesions restricted to the prerolandic, or "Anterior" region of the nondominant hemisphere (four patients, including one who was over 65 years of age); (b) those with perirolandic, or "Central" lesions (seven patients); (c) those with large, or "Extensive" lesions, including anterior, parietal, and temporal areas (four patients, of whom three were over 65 years of age); and (d) those with lesions restricted to the postrolandic, or "Posterior" region (one patient).[2]

---

[1] Performances on the two matched narratives were roughly equivalent; thus findings of differences between performance with the filmic *Fence* and the orally presented *Hammer* can validly be attributed to differences in media of presentation, and not to differences in the narrational structures of the two stories.

[2] This patient, who had an occipital lobe lesion which spared the temporal and parietal lobes, performed normally on the test battery. Therefore, this patient has been excluded from the analyses reported below.

In addition, three groups of control subjects, all of comparable educational and socioeconomic background, were tested. First, 10 patients with left-hemisphere brain damage received all but the test of humor (which was assumed to be too linguistically complex for them). This population consisted of five nonfluent aphasics with good comprehension and lesions restricted to the anterior region of the dominant hemisphere; and five fluent aphasics with impaired comprehension, paraphasic speech, and lesions restricted to the posterior (temporo-parietal) region of the dominant hemisphere. Two groups of non-brain-damaged subjects were also tested on the battery, including one group of 10 subjects aged 45 to 65 and one group of 5 "aging" subjects (65 to 85).

A population of aging adults was included as a control group for two reasons. First, it has been hypothesized that as people age, right-hemisphere functions deteriorate more rapidly than left-hemisphere abilities (Kaplan, 1977). Therefore, it is important to confirm that any patterns discerned in the performance of the right-hemisphere patients are a result of acute onset of right brain damage and not of a normally aging brain. In addition, even if the hypothesis of more rapid deterioration in aging patients of right-hemisphere functions is not substantiated, findings obtained with that population should permit tentative conclusions on an important question: which difficulties on the battery might be obtained with any group performing in a suboptimal fashion, and which difficulties might be restricted to or highlighted in individuals with documented focal injury in the right hemisphere.

Procedure

Subjects were tested in four to five half-hour sessions in a quiet testing room. All storytelling responses were tape recorded. Responses to multiple choice and ordering tasks were recorded by the experimenter. Order of presentation of items and conditions within each test was varied across subjects; in addition, the order of test presentation across subjects receiving the whole battery was varied.

Hypotheses

A number of hypotheses were tested in one or more of the particular tasks:

1. Straight linguistic processing. In the story recall conditions, right-hemisphere patients should use appropriate phonology and syntax. In addition, such patients should recall elementary facts (e.g., time, names) with no difficulty.

2. Appreciation of and integration within narrative materials. Reflecting their tendencies to focus on isolated details, make tangential or inappropriately personal remarks, and miss the overall point of a discussion, right-hemisphere patients should have difficulty inferring the moral of a story, correctly ordering segments of a story and, more generally, in appreciating the underlying structure of narrative forms—the existence of and hierarchical relations obtaining among principal sections of a story, such as setting, major plot lines, sources of conflict and their resolutions. In addition, they should exhibit deficits in distinguishing major themes from minor details, and in inhibiting personal details and confabulations from intruding in their recountings. Finally, owing to difficulties in logical inference and integration of disparate elements, such patients should be impaired in their ability to detect incongruities in the narrative.

3. Integration of specific story elements. Consistent with their demonstrated difficulties in processing certain kinds of contents, right-hemisphere patients should exhibit special difficulties in recalling and integrating spatial, emotional, motivational, and noncanonical elements of stories. In contrast, temporal and categorical forms of information should be handled with little or no difficulty.

4. Humor. Reflecting their difficulties in integrating materials, and in exhibiting appropriate emotional responses, right-hemisphere patients should exhibit difficulties in choosing the correct punch line to accompany a joke. More generally, throughout the testing, right-hemisphere patients should exhibit inappropriate reactions, emit inappropriate mirth responses, and fail to appreciate incongruities in their own remarks or in the noncanonical elements of the stories.

5. Comparison to aging patients. In comparison to aging patients, right-hemisphere patients should perform equally well in straight linguistic processing, but have more pronounced difficulties than aging patients in appreciating the overall meaning of stories and to exhibit greater tendencies to confabulate, inject personal elements, and lose the thread of the story.

RESULTS AND DISCUSSION

Straight Linguistic Processing

Turning first to ordinary language processing, it was found that right-hemisphere patients exhibited no difficulty in using appropriate phonology and syntax. They recalled elementary facts with relatively little difficulty. In fact, in some cases their ability to recollect specific phrases and even entire sentences was remarkable. Whereas normal controls characteristically paraphrased the stories, 10 of the 15 right-hemisphere patients repeated segments of the prose just as given without recoding it into more concise or abstract form. The only pronounced abnormality was the flat mode of delivery which characterized many patients' retellings of stories and answering of questions.

Appreciation of and Integration of Narrative Materials

Right-hemisphere patients had difficulty both in integrating the elements of a story and in appreciating the "narrative form" of a story. Required in the Story Arrangement Task to organize story elements logically, right-hemisphere patients were markedly impaired. They performed significantly worse than the non-brain-dmaged control group, and their performance was on a par with that of the aphasic patients (normal controls = 78% correct, right-hemisphere patients = 45% correct, aphasic patients = 40% correct). Thus, while right-hemisphere patients are unimpaired in straight linguistic processing, right- as well as left-hemisphere-damaged patients are impaired in organizing linguistic information at the narrative level (cf. Delis, 1980).

Right-hemisphere patients also had difficulty inferring the correct point or moral of a story. For example, on the Silver Hammer story, normal subjects answered correctly 70% of the time, while the right-hemisphere patients gave the correct moral only 50% of the time. Figures for the other groups were 44% for the aging individuals, and 30% for the left-brain-damaged patients. When answering incorrectly, right-hemisphere patients tended either to simply repeat the plot, or to give a literal response (20% of their responses were literal vs. 5% for the other groups). Examples of literal responses frequently given by right-hemisphere patients were "keep clean" and "take care of your tools" for *The Silver Hammer,* and "keep trash in your own yard" and "never grow a house in front of a flower'' for *The Fence,* rather than giving a correct moral, such as the Golden Rule (''Do unto others as you would have others do unto you''). One patient, when given four proverbs and asked to identify the one most representative of *The Fence,* chose at first, ''People who live in glass houses shouldn't throw stones,'' adding as justification that the man ''threw a lot of stones and his house collapsed.'' However, the patient reconsidered this choice, saying, ''But he didn't live in a glass house! He lived in a brick house, and he had windows and doors.''

Whereas aphasic patients were not eloquent, they often managed to convey the point (e.g., ''everybody gets along''). When aging patients erred, the response was moralistic, but had a more personalized message to it (e.g., ''if you keep busy and active, you won't become bored'').

Subjects were also asked to account for the characters' motivations for some of their actions. Right-hemisphere patients were able to do this adequately when the motivations and actions were straightforward, for example, when the carpenter carved something for his partner as a peace offering. However, when asked why the man threw his flower over the fence, right-hemisphere patients were unable to make the leap from ''it is wrong to throw things'' to ''he is offering his prize possession as a gesture of reconciliation.'' On this question, only 22% of the right-hemisphere patients' responses were correct, dramatically lower than the aphasic patients' correct responses (90% correct) and the normal groups' responses (80% correct). The right central patients performed especially poorly—not one central patient answered this question correctly. Typical right-hemisphere responses were that the man threw the flower over the fence because ''he was a loser,'' because ''he's so frustrated he says to himself, 'it isn't worthwhile trying to grow a garden',' and because ''if it comes back, at least it won't hurt anything.''

Further evidence of a lack of sensitivity to ''narrative form'' in right hemisphere patients was the abundance of embellishments (i.e., extraneous or unnecessary comments or additions to the story) which they made in the stories featuring differing content. Of 15 patients, all but one elaborated at some point in their retelling for a total of 74 embellishments. Embellishments occurred approximately three times as often in right-hemisphere patients' stories as in left-hemisphere patients' or normals' stories.

Examination of performances by subgroups revealed that within right hemisphere groups, it is those patients with large anterior lesions who most frequently embellish their stories (Anterior = mean number of 7.75 embellishments per patient; Extensive = 6.5 per patient; Central = 2.4 per patient). Within the left-hemisphere patients, posterior (fluent) aphasics embellish far more than the anterior (nonfluent) aphasics (Posterior = 2.4 embellishments per patient vs. Anterior = .4 per patient). Aging subjects averaged 1.8 embellishments per subject.

Of the embellishments made by right-hemisphere patients, those which signaled an unwillingness to accept the story on its own terms were particularly noteworthy. Six patients (drawn from all three subgroups) actually argued with points in the story. One patient insisted that the story about the fireman and the little girl was incorrect because alleyways could not be located near a firehouse. Finding additional faults, he commented, "no kid could sneak on a fire engine; they can ring the bells in a firehouse but not ride on engines." A second patient commented similarly that "only authorized people are allowed to ride on a fire engine," while a third patient refused to allow a grocery store on a side street "because it doesn't make sense to be on a deserted street."

Other embellishments consisted of additions to or changes in the story. One patient, while retelling the Fireman story, said, "Ask me where the fire was at . . . well, they went someplace and there was actually no fire." Another patient, after finishing his retelling, pointed to the experimenter and added, "They called her mother, and said *you* were there."

These frequent intrusions suggested that, rather than respecting the story as a separate fictive entity, patients allowed personal memories and associations, differences of opinions, and asides to surface as part of the story. Constantly violating the boundary of the stories, the patients seemed uncertain about the difference between what could happen and what actually did happen. Indeed, three patients justified embellishments by saying "it could have happened," while several indicated that their embellishments improved the story.

Going beyond mere embellishment, nine patients engaged in sheer confabulation—inventing parts of a story and/or magnifying an insignificant detail out of all proportion. Of the 74 embellishments, 27 (36%) were sheer confabulations. All four Anterior patients confabulated (making 56% of all right-hemisphere confabulations) and three of four Extensive patients confabulated (37%); only two Central patients confabulated (7% of all confabulations). As instances of these sheer confabulations, one patient stated that the robber in one story had stolen all of the grocer's groceries (instead of money) and that, as he was escaping, he "tripped on a bad sidewalk, fell down, and broke all the eggs." Another patient, retelling the story of the hired hand, said that the hand (who was actually sleeping in a haystack instead of repairing a hole in the barn) had gone to the back of the barn to get out of the rain. Occasionally patients showed some uncertainty about the status of their confabulation (one said "that would have made a better story"), but in general the confabulations provide further evidence of the difficulty experienced by these patients in separating out the actual plot from their own inventions.

Sheer confabulations were rarely found in the stories of the other groups: none were made by any of the five anterior aphasics, three were made by posterior aphasics, and only one was made by an aging subject.

Integration of Specific Story Elements

Contrary to expectation, the story elements hypothesized to pose special difficulty for right-hemisphere patients did not prove particularly troublesome. In the Story Arrangement Task, there were no differences in the patterns of performance by right-hemisphere, left-hemisphere, or control subjects on the three types of story elements tested. All groups were most successful when ordering temporal elements, least successful with categorical elements.

In the stories featuring different contents, there were only 13 errors in the 80 opportunities for error on the noncanonical elements (7 of these errors by Anterior, 4 of these by Central, and 2 of these by Extensive subjects), and 16 errors in the 80 opportunities for spatial errors (7.5 by Anterior, 6 by Central, and 2.5 by Extensive subjects). Emotional elements proved somewhat more difficult, eliciting a total of 23.5 errors in the 80 opportunities for error (6.5 by Anterior, 12.5 by Central, and 4.5 by Extensive subjects). These results suggest that the different semantic contents can be handled merely by consulting the lexical entries for specific words and may not necessitate reliance on spatial or emotional imagery.

While these elements in general proved less problematic than anticipated, each of them requires further comment. Turning first to the spatial elements, it may be that, while spatial information poses little difficulty when encoded directly into linguistic form, it remains vulnerable when it must be drawn upon for an appreciation of the structure of the story. The difficulties patients have in relating different portions of the story to one another, and integrating them into a coherent whole, may well depend upon spatial mechanisms, though ones of a far more abstract (or metaphoric) sort than are needed to conceive of sheer location.

The emotional elements proved more difficult to master. The problems posed by the emotional elements are suggested by the fact that almost half of the errors triggered inappropriate embellishments. That is, when a patient attributed an incorrect emotion to the character under consideration, the patient went on to elaborate a reason why that was indeed the emotion that the character was feeling. For example, in the Fireman Story, one patient said that the little girl "didn't express any opinion or feelings except being excited. She didn't wet her panties, she didn't kiss anybody around . . . and she didn't hug anybody."

Though often at variance with the emotions implied in the stories, the emotions stated by the patients were typically ones which could logically have been involved. Indeed, of the 23.5 errors, only 7 of them were illogical (5 of these (3 by one patient) were made by Central patients; 2 were made by Extensive patients; and none were made by Anterior patients). Characteristically, the patients made inferences about how a character could have felt but not how he actually felt. This finding is consistent with results from an earlier study of emotional sensitivity among right-hemisphere patients (Cicone et al. 1980). There, as in the present study, patients often designated an emotion other than the one actually portrayed but then produced a reasonable explanation (or confabulation) for the stated emotion. Taken together, such findings suggest that the patient's ability to make logical inferences about the emotional sphere (as in the spatial sphere) seems unimpaired; however, the ability to marshall this logic in order to appreciate a particular story or scene is compromised. Possibly this result may reflect a kind of functional dissociation between the ability to make logical inferences about emotions and the ability to attribute emotions appropriately to situations. In other words, patients can marshall appropriate routines for inference, but invoke them inappropriately.

It is worth noting that, whereas right-hemisphere patients made the most errors on the emotional elements, the left-hemisphere and aging subjects made fewer errors on the emotional elements (1.1 and 0.6) than on either the spatial (1.3 and 1.0) or noncanonical elements (1.4 and 0.8 respectively). Again, in contrast to the right-hemisphere patients, the aging subjects frequently mentioned emotional and motivational states of the story characters spontaneously, while forgetting names and places less relevant to the point of the story.

Most dramatic was the right-hemisphere patients' difficulty in reacting appropriately to the noncanonical (or bizarre) story elements. Normal and aging controls and Anterior aphasics typically found these elements funny, as they were clearly at variance with the rest of the story and, to some extent, with stories in general. All these control groups looked puzzled when they heard the noncanonical sentences read to them and, in recall, they characteristically omitted, regularized, or challenged the jarring elements. Whereas posterior aphasics made a great number of errors on the noncanonical elements ($\bar{X} = 2.4$ errors per patient), nearly twice as many as on the spatial ($\bar{X} = 1.6$) or emotional ($\bar{X} = 1.2$) elements, their errors consisted primarily of revising the bizarre sentences into logical and more appropriate versions of events. Because these patients may have been uncertain of having accurately heard the sentence, or because they simply could not comprehend enough of the sentence to appreciate its incongruity, they tended to report the events as they *should* have been.

In sharp contrast, the right-hemisphere patients actually recalled these elements better ($X = 0.8$ errors per patient) than the spatial ($X = 1.0$) or emotional ($X = 1.6$) elements and about as well as regular, canonical elements of the story. In addition to accepting these elements in their recall, these patients frequently added explanations to justify their inclusion in the story. Ten patients (all four Anteriors, four of the seven Centrals, and two of the Extensive patients) justified these noncanonical sentences a total of 23 times. For example, asked why a lazy hired hand had received a raise in one story, patients were quick to justify the sentence. Four typical responses were: "The cost of living is up"; "Maybe he thought he wasn't paying him enough"; ". . . to encourage him to work a little harder"; "He thought he was such a good worker he'd give him a raise."

Indeed, one patient felt such a need to justify these noncanonical elements that, even after acknowledging puzzlement at them, he proceeded to figure out a way in which they *could* make sense. Thus, in *The Fishing Trip*, when the father tells his son never to bring a flashlight on a boat after having just been rescued because of it, this patient said it was "nonsensible" but continued on to comment, "he was trying to collect his son's insurance." Similarly, when in another story a farmer gives his hired hand a raise after finding him asleep in a haystack, his job left undone, this patient realized "it was inconsistent with the rest of the story" yet went on to justify it: "The guy quits—no discussion or anything—the farmer meets him and raises his wages. 'Say hey Joe—if you're gonna quit, I'm raising your wages; it won't cost me a cent, you won't be here!' "

Such rationalizing behavior may be rooted in two different causes. In some circumstances, or for some patients, the subject fails to appreciate that the noncanonical elements are far-fetched and thus are unable to appreciate their incongruity with the rest of the story. In other instances, the subject may sense that the elements are in some way incongruous, and yet feel the need to justify them, if necessary, confabulating in order to create a link. To summarize, right-hemisphere patients accept and justify the noncanonical elements; posterior aphasics change and normalize these elements; and all other subjects tend to omit or reject them.

Sense of Humor

In addition to their anomalous reactions to the noncanonical elements in the straight stories, the right-hemisphere patients performed poorly on the test of humor. Patients were particularly attracted to the incorrect non sequitur endings, choosing this type of ending three times as often as normal controls (18.8% and 6.3%, respectively). In a manner reminiscent of their behavior on the test of emotional sensitivity (Cicone et al., 1980), patients would frequently confabulate a tie between the non sequitur and the body of the joke. Indeed, they sometimes seemed to value the very anomalousness of the ending. For instance, in a joke about a parade, a patient chose the non sequitur, "I wonder what's for dinner tonight." Asked why this choice was humorous the patient responded, "Why are they worrying about dinner if they're worrying about the parade?" Incapable of relating the body of the joke, designed to "set up" the ending, with the actual punchline, the patients may have been reduced to selecting something which had as its sole justification the fact that it was a surprise.

As a supplement to the Joke Test, patients were also presented a cartoon series of three pictures, one of which invariably drew smiles or laughs from aphasic patients and normal controls (Landis, 1979). The right-hemisphere patients not only failed to appreciate the humor but did not even realize that the series was supposed to be funny. As in the story retelling task, their reactions were serious and critical. One patient said (with respect to the final, funny frame), "The first thing I'd like to know is how the elephant got up that tree." Clearly this patient was unable to accept the "cartoon" world as different from the "real" world.

Comparisons to Aging Subjects

As already noted, the most obvious control group for the right-hemisphere patients—that of aphasic patients—is not wholly appropriate for this investigation. Thus, findings from our other control group of aging subjects assume importance.

We have found that in certain respects, the aging patient performs less well than the right-hemisphere patient. The aging patient is more likely to be wordy, more given to circumlocutions, less able to "get out" what he wants to say. Word-finding pauses are frequent and the memory for specific facts is often poor (Obler, 1979). In these respects the right-hemisphere patient remains a more efficient processor of language.

As opposed to the younger control group, our five aging subjects also show certain superficial similarities to the right-hemisphere subjects, for example, making personal remarks and embellishments. Yet, the quality of response is generally different. For example, when aging patients make personal remarks, they are often of a moralistic nature, and seldom cause the patients to drift away from the main point of the story. Indeed, the aging individual seems quite able to remember the major point of the story and to ferret out the moral—if anything, his overall story schema seems well preserved, while his attention to details is more compromised. By the same token, relatively secure about the overall contents of the story, the aging subject, in contrast to the right-hemisphere subject, will concede when he does not remember a point and will rarely resort to sheer confabulation. In short, in the aging patient, the scaffolding remains while the details fade; in the right-hemisphere patient, the picture is reversed.

CONCLUSIONS

The general picture of right-hemisphere patients gleaned from earlier studies and from clinical observations has been supported by the current test battery. Overall, the patients exhibit a striking amount of difficulty in handling complex linguistic materials. While their ability to remember isolated details and wordings is often preserved, they have clear difficulties in integrating specific information, in drawing proper inferences and morals, and in assessing the appropriateness of various facts, situations, and characterizations.

Some islands of spared capacity were also observed. The patients were more successful than had been hypothesized in handling specific contents—spatial and emotional, in particular—possibly because these contents can be handled exclusively on the lexical level and do not require the access of special imagery. Nonetheless, the patients often demonstrated difficulty in making the proper inference about contents, particularly emotional ones. This difficulty seems due less to a deficit in logical inference per se—answers often reflected what *could* have happened—and more to a dampened appreciation of the kind of emotion which was in fact experienced by the individual in question. Relatedly, the patients' apparent insensitivity to incongruities reflected, at least in some cases, a compulsion to justify the bizarre incongruity, rather than a total insensitivity to the incongruity. Patients seem at least tangentially aware that something does not fit and yet, are either unwilling or unable to frankly label the anomalous element as such.

One alternative way of conceptualizing many of the present findings is to attribute the results to a difficulty in handling complex ideational materials, rather than to deficits in the processing of complex linguistic materials. To some extent, this characterization hangs on definitional factors; one certainly can characterize many of the defects in terms of ideational or conceptual factors, rather than in terms of linguistic ones. Indeed, it would require the construction and administration of a lengthy new test battery in order to cleave apart the contributions of general conceptual impairments to the present symptom picture. Nonetheless, the characterization in terms of linguistic deficits seems justifiable, both because of the current tendency to incorporate issues of discourse and narration into the realm of linguistics proper, and because of the putative existence of integrative capacities which are particularly appropriate to narrational–linguistic materials (Rumelhart, 1975). Finally, the superior performance of aphasic patients in inferring the major points and the moral of stories presented in the visual form documents that, at least in this patient group, language deficits do not necessarily entail conceptual impairments.

The small size of the population dictates caution in attributing specific deficits to sites within the right hemisphere. Nonetheless, the limited amount of data available points to a particular tendency to embellish, and a lack of sensitivity to noncanonical elements, which is particularly heightened in patients with damage in the anterior zones of the right hemisphere. In contrast, a tendency to commit errors with emotional materials seems more specifically associated with injury to the central (temporo–parietal) regions of the right hemisphere. Of the various contents provided in these tests, right-hemisphere patients exhibited, as a group, more difficulty with the emotional contents, while difficulty with spatial elements could not be as strongly lateralized to one or another hemisphere.

Whatever the role of specific sites in the right hemisphere in yielding particular deficits, the findings summarized above suggest some tentative formulations about difficulties exhibited by right-hemisphere patients as a group. One way of conceptualizing the difficulties of these patients is to invoke the notion of a "plausibility metric." Normal individuals, it can be hypothesized, can assess, with reference to a given element, whether that element is appropriate to a given context. Just this ability to assess plausibility seems to be vitiated in many right-hemisphere patients. Thus, even as a patient may challenge a statement which normal controls consider to be perfectly plausible, the same patient may accept, or even strive to justify, that noncanonical element which is immediately challenged or ignored by a normal control. Bereft of a structure into which to place the element, unaware of (or insensitive to) the rules which generally govern discourse in an area, the patient must make an assessment based only on the element itself. And so, when a patient's individual answer or remark is examined without respect to context, it is generally appropriate. But when wider contexts—the general setting, the purpose of the interchange, previous and successive events—are taken into account, the patient's inappropriateness stands out. As if to provide further confirmation for this result, it should be stressed that the right-hemisphere patients virtually never respond "I don't know" to an open-ended question. Instead, they generally contrive an answer—confabulating if necessary—in seeming indifference to the inappropriateness of the response.

Another, somewhat more abstract way of characterizing the difficulties of these patients is to stress their problems in acquiring a sense of the overall gestalt or form of linguistic entities. Patients seem unable to appreciate the relations among the key points of the story or the joke. The basic schema—the major episodes organized in a hierarchically appropriate manner—seems disturbed, if not totally destroyed, while it may well be spared even in linguistically compromised left hemisphere patients (cf. Stachowiak, Huber, Poeck, & Kerschensteiner, 1977). To be sure, when memory is sufficiently acute, or cues sufficiently abundant, subjects may well mention all the major points. But their inability to negotiate noncanonical elements, their frequent confabulations, embellishments, and injections of personal details, all suggest that the basic scaffolding of the story has not been apprehended. Without an organizing principle, the patients are consigned to undirected rambling, unable to judge which details matter, and what overarching points they yield.

In closing, we must stress that this portrait of the linguistic capacities of the right-hemisphere patient is still preliminary and incomplete. It is not known, for example, to what extent specific characteristics apply to all right-hemisphere patients, or only to patients with lesions in a certain site, or of a certain size. Many of the results reported here have also been cited with reference to frontal lobe pathology and it will be important in future studies to determine which of the response patterns seem better attributable to frontal pathology (irrespective of hemisphere), which to parietal or temporal disease, and which seem an accompaniment of any significant right-hemisphere pathology. Also, though the right-hemisphere patients seem to differ in certain respects from the normal aging individual, the precise profile of performance characterizing both groups has yet to be ascertained.

The foregoing analyses suggest a fairly coherent, if still highly tentative picture of the language pathology of significantly impaired right-hemisphere patients. Confronted with complex linguistic entities, such patients exhibit clear and recurring difficulties, relating to the abilities to conceptualize the unit as a whole, to appreciate its purpose and its form, and to integrate specific elements appropriately within these forms. Correlatively, many of the patients seem insensitive to the context in which these linguistic entities are produced and utilized. Finally, they seem unable to honor the world of the fictive, the imaginary, the humorous—they seem uncertain how to relate to these entities and, in fact, sometimes appear as if they are unaware altogether of their existence as separate and specifiable forms of language.

It is possible to schematize the emerging picture in terms of two contrasting axes. On the horizontal axis are arrayed, at one end, certain canonical or "straight" aspects of language: phonology, syntax, literal lexical entities, which may require sheer computational capacities. At the other end of this horizontal axis are arrayed more complex linguistic entities, ones which entail redundant information, nonliteral information, and information which requires integration across the boundary of the word or clause (e.g., jokes, stories, adages). Right-hemisphere patients consistently perform better with the more canonical aspects, worse with the more complex (even as left-hemisphere patients may exhibit an opposite pattern—cf. Dennis, 1980; Eisenson, 1962; Stachowiak et al., 1977; Winner & Gardner, 1977).

The vertical axis maps the extent to which pragmatic and paralinguistic features contribute to the comprehension of a linguistic entity. At one end of an axis one can place the ideal "content-free" situation: a simple assessment of whether a word is spelled or defined correctly, whether a sentence is syntactically acceptable, whether a story has an appropriate beginning or ending. Contextual information plays a minimal role here. At the opposite end of the axis are situations in which contextual information is wholly or largely determinant—telling a joke, understanding the underlying intention of a question or comment, judging the plausibility of a particular fact within an adventure story or a fairy tale. Once again, it is on these contextualized linguistic assignments that right-hemisphere patients are disproportionately impaired. It is as if the left hemisphere is a highly efficient, but narrowly programmed linguistic computer; in contrast, the right hemisphere constitutes a suitable audience for a humorous silent film. While the left hemisphere might appreciate some of Groucho's puns, and the right hemisphere might be entertained by the antics of Harpo, only the two hemispheres unified can appreciate a whole Marx Brothers' routine.

REFERENCES

Bates, E. 1976. *Language and context: The acquisition of pragmatics.* New York: Academic Press.

Blumstein, S. E., & Cooper, W. E. 1974. Hemispheric processing of intonation contours. *Cortex,* **10,** 146–158.

Caramazza, A., Gordon, J., Zurif, E. B., & DeLuca, D. 1976. Right-hemispheric damage and verbal problem solving behavior. *Brain and Language,* **3,** 41–46.

Cicone, M., Wapner, W., & Gardner, H. 1980. Sensitivity to emotional expressions and situations in organic patients. *Cortex,* **16,** 145–158.

Curtiss, S., Fromkin, V. A., & Krashen, S. D. In press. Language development in the mature (minor) right hemisphere. *ITL: Review of Applied Linguistics.*

Delis, D. 1980. *Hemispheric processing of discourse.* Dissertation, University of Wyoming.

Dennis, M. 1978. *Language acquisition mechanisms of the two hemispheres.* M.I.T. Workshop on Cognitive Science, Boston, MA, June.

Dennis, M. 1980. *Reading following surgical removal of one hemisphere.* Colloquium presented at the Boston Veterans Administration Medical Center.

Dennis, M., & Whitaker, H. 1976. Language acquisition following hemidecortication: Linguistic superiority of the left over the right hemisphere. *Brain and Language,* **3,** 404–433.

Eisenson, J. 1962. Language and intellectual modifications associated with right cerebral damage. *Language and Speech,* **5,** 49–53.

Gainotti, G. 1972. Emotional behavior and hemispheric side of lesion. *Cortex,* **8,** 41–55.

Gardner, H. 1975. *The shattered mind.* New York: Knopf.

Gardner, H., & Denes, G. 1973. Connotative judgments by aphasic patients on a pictorial adaptation of the semantic differential. *Cortex,* **9,** 183–196.

Gardner, H., Ling, K., Flamm, L., & Silverman, J. 1975. Comprehension and appreciation of humor in brain-damaged patients. *Brain,* **98,** 399–412.

Gardner, H., Silverman, J., Wapner, W., & Zurif, E. B. 1978. The appreciation of antonymic contrasts in aphasia. *Brain and Language,* **6,** 301–307.

Gazzaniga, M., 1970. *The bisected brain.* New York: Appleton–Century–Crofts.

Geschwind, N., 1976. *Approach to a theory of localization of emotion in the human brain.* Paper presented at the International Neuropsychological Symposium, Roc-Amadour, France.

Heeschen, C., 1979. Personal communication, October.

Heilman, K. 1976. *Affective disorders associated with right hemisphere disease.* Invited address to Aphasia Academy, Miami, FL, October.

Heilman, K., Schwartz, H., & Watson, R. 1978. Hypoarousal in patients with the neglect syndrome and emotional indifference. *Neurology,* **28,** 229–232.

Jackson, J. H. 1932. *Selected writings of John Hughlings Jackson.* London: Hodder & Stoughton.

Kaplan, E. 1977. Personal communication.

Kimura, D. 1967. Functional asymmetry of the brain in dichotic listening. *Cortex,* **3,** 163–178.

Kimura, D. 1973. Functional asymmetry of the human brain. *Scientific American,* **228,** 70–78.

Landis, T. 1979. Personal communication, July.

Lezak, M. D. 1979. *Behavioral concomitants of configurational disorganization in right hemisphere damaged patients.* Unpublished paper, Portland, OR.

Mandler, J. M., & Johnson, N. S. 1977. A structural analysis of stories and their recall: From "Once upon a time" to "Happily ever after." *Cognitive Psychology,* **9,** 111–151.

Michel, D. 1980. Work in progress.

Myers, P. S. 1979. *Profiles of communication deficits in patients with right cerebral hemisphere damage: Implications for diagnosis and treatment.* Paper presented at the Clinical Aphasiology Conference, Phoenix, AZ.

Obler, L. 1979. *Narrative discourse style in the elderly.* Paper presented at Language and Communication in the Elderly, Boston, MA.

Ross, E. D., & Mesulam, M. M. 1979. Dominant language functions of the right hemisphere: Prosody and emotional gesturing. *Archives of Neurology,* **36,** 144–148.

Rumelhart, D. E. 1975. Notes on a schema for stories. In D. G. Bobrow & A. M. Collins (Eds.), *Representation and understanding.* New York: Academic Press.

Sadock, J. 1974. *Toward a linguistic theory of speech acts.* New York: Academic Press.

Searle, J. 1969. *Speech acts.* Cambridge: Cambridge Univ. Press.

Searleman, A. 1977. A review of right hemisphere linguistic capabilities. *Psychological Bulletin,* **84,** 503–528.

Sperry, R. 1974. Lateral specialization in the surgically separated hemispheres. In F. O. Schmitt & F. Worden (Eds.), *The neurosciences third study program.* Cambridge, MA: MIT Press.

Stachowiak, F. J., Huber, W., Poeck, K., & Kerschensteiner, M. 1977. Text comprehension in aphasia. *Brain and Language,* **4,** 177–195.

Stein, N., & Glenn, C. G., 1979. An analysis of story comprehension in elementary school children. In R. Freedle (Ed.), *Multidisciplinary approaches to discourse comprehension.* Hillsdale, NJ: Ablex.

Wechsler, A. 1972. The effect of organic brain disease on recall of emotionally-charged versus neutral narrative texts. *Neurology,* **73,** 130–135.

Weinstein, E. A. 1971. Linguistic aspects of amnesia and confabulation. *Journal of Psychiatric Research,* **8,** 1–7.

Whitaker, H. A., 1978. The fallacy of the split brain research. *SISTM Quarterly,* **2,** 8–10.

Winner, E., & Gardner, H. 1977. Comprehension of metaphor in brain-damaged patients. *Brain,* **100,** 719–727.

Woods, B. 1979. *The lateralization of language functions during childhood.* Paper presented at the Academy of Aphasia, San Diego, CA, October.

Zaidel, E. 1973. *Linguistic competence and related functions in the right hemisphere of man following cerebral commissurotomy and hemispherectomy.* Doctoral dissertation, California Institute of Technology.

Zaidel, E. 1977. Unilateral auditory language comprehension on the Token Test following cerebral commissurotomy and hemispherectomy. *Neuropsychologia,* **15,** 1–8.

Zaidel, E. 1978. Auditory language comprehension in the right hemisphere following cerebral commissurotomy and hemispherectomy: A comparison with child language and aphasia. In A. Caramazza & E. B. Zurif (Eds.), *Language acquisition and language breakdown: Parallels and divergences.* Baltimore: Johns Hopkins Press. (a)

Zaidel, E. 1978. The elusive right hemisphere of the brain. *Engineering and Science,* **42.** (b)